REMARKS

Claims 1 to 22 are present in this application. Claims 1 and 12 are independent claims.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

Election Requirement

In the Election of Species of January 31, 2007, Applicants had elected Species II, shown in Figs. 2 or 3, which is covered by claims 1-3, 5, 6, 12-14, 16, and 17. Rather than examining all of the elected claims, the Examiner has examined only claims 1 and 12. The Examiner alleges that claims 2, 3, 5, 6, 13, 14, 16, and 17 are not directed to the elected invention of Figs. 2 and 3. Applicants disagree.

Applicants submit that claims 2, 3, 5, 6, 13, 14, 16, and 17 are directed to the invention of Figures 2 and 3 and should be examined as being directed to the elected species.

The Examiner states that page 20 of the specification might be said to disclose that the differential amplifier is switched, but it does not disclose selection of a single resistive element. The Examiner further states that, "there is simply no switch in the elected invention that selects "one" of the resistive elements." (Office Action at page 3).

Applicants somewhat agree with the Examiner's statements. Applicants do not agree, however, that the claims recite a "switch."

In an embodiment of the present invention (e.g., Figs. 2 or 3), there are two differential amplifiers and one is selected based on wavelength (e.g., differential amplifiers A3, A4). This enables only those resistors that are associated with the selected differential amplifier to contribute to temperature. In other words, by selecting a differential amplifier, an associated set

of resistors is selected. Thus, Applicants submit that the claims do not recite a "switch", but do cover the embodiment related to Figs. 2 or 3.

Applicants request that claims 2, 3, 5, 6, 13, 14, 16, and 17 be examined as being directed to the elected species.

Specification

The disclosure is objected to because of several informalities. Applicants respectfully disagree.

The Examiner objects to the specification due to the reference numbers Rf3, Rs4, etc., which the Examiner alleges are not shown in the drawings. Applicants note that the specification refers to Rf3, Rf4, Rs3, Rs4, etc. in various places throughout the specification (e.g., pages 12, 21, 23, 31) for purposes of simplifying the disclosure of formulas and for indicating the equivalence between resistors. For example, the specification at page 12 states, "assuming that Rf31 = Rf32 = Rf3, Rf41 = Rf42 = Rf4, Rs31 = Rs32 = Rs3, Rs41 = Rs42 = Rs4. Fig. 2 shows Rf31, Rf32, Rs41 and Rs42, such that Rf3 and Rs4 would be apparent from the disclosed expression.

Applicants submit that the specification is clear, and that necessary reference symbols sufficient to clearly disclose the present invention are shown in the drawings.

The Examiner objects to the specification due to the units for sensitivity, conversion efficiency, and temperature coefficient. Applicants note that the units disclosed in the specification would be understood by one of ordinary skill in the art of electrical engineering.

The units for sensitivity S, which in the case of the present invention is of the photoreceptive amplification circuit of a photodiode, are V/W, where V is volts and W is watts (see formula for sensitivity at page 12). The units of V/W can also be obtained from the relationship η[A/W] for conversion efficiency. In this relationship, A (ampere) is equivalent to V/R. Thus, expressing η as (V/R)/W, gives a sensitivity in units of V/W based on the formula on page 12 of the specification.

It follows that the units for conversion efficiency of the photodiode is A/W, where A is ampere and W is watts.

In the units for temperature coefficient of the sensitivity, ppm is parts per million as noted by the Examiner.

As evidence that these units are common for the disclosed parameters, Applicants provide documents attached hereto.

§ 102(b) Rejection – Miyano

Claims 1 and 12 have been rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent 5,912,590 (Miyano). Applicants have amended claims 1 and 12. Applicants traverse this rejection based on the claims as amended.

According to the present specification, the feedback resistor Rf1 and the resistors Rf3 and Rs3 make up a group of resistors for the differential amplifier A3 for a DVD disk with a wavelength of 650nm (specification at page 14). The arrangement of the group of resistors provides a temperature coefficient of 0 for the output of the differential amplifier.

Also, the feedback resistor Rf2 and the resistors Rf4 and Rs4 make up a group of resistors for the differential amplifier A4 for a CD-type disk with a wavelength of 780nm. Again, the arrangement of the group of resistors provides a temperature coefficient of 0 for the output of the differential amplifier.

Thus, the temperature coefficient is 0 for the output of the photoreceptive amplifier circuit regardless of the wavelength of incident light. (specification at page 14, last paragraph).

Claims 1 and 12 have been amended to clarify this aspect of the invention. Applicants submit that Miyano fails to teach or suggest at least this aspect of the present invention.

As indicated in the Office Action, the component 37 in Fig. 1 of Miyano appears to teach a former-stage amplifier. However, Applicants submit that Miyano fails to teach this former-stage amplifier as including a feedback resistor.

Resistor R2, which is alleged as teaching the claimed feedback resistor, is disclosed as a bias resistor R2 provided in parallel with diode D2 between the base and collector of the transistor Q1. (col. 6, lines 32-36). Thus, resistor R2 does not constitute a feedback resistor.

Thus, Applicants submit that Miyano fails to teach at least the claimed "former-stage amplifier including a feedback resistor."

Furthermore, the Examiner appears to have read the claims in a manner that was unintended. For example, the Office Action states that "resistive elements having different temperature characteristics" would occur in the real world since temperature characteristics of resistive elements will never be exactly the same. The term "temperature characteristics" was intended to mean a parameter of the resistors. In order to clarify the intended meaning the claims have been amended to include the term "temperature coefficient." Applicants submit that Miyano fails to teach a temperature coefficient for each wavelength being 0, as recited in the claims.

Thus, Applicants submit that the rejection fails to teach each and every claimed feature. Accordingly, the rejection fails to establish *prima facie* anticipation. Applicants request that the rejection be reconsidered and withdrawn.

Conclusion

In view of the above remarks, it is believed that claims are allowable.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact **Robert Downs** Reg. No. 48,222 at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.14; particularly, extension of time fees.

Dated: May 29, 2007

Respectfully submitted,

By Robert C. Downs #48,222

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Attachments

[Document ①-1]

Electric/Electronic Engineering Compendium 15

Photoelectric Conversion Devices

...

Photoelectric Conversion Devices 76.9.12

[Document ①-2]

A signal generally has a voltage V_0 in response to an input P_{in} entering an infrared light receiving face, so that responsivity is defined by a ratio to the output voltage V_0. At this time, the input light is chopped and the output is in a form of a voltage pulse, so that they are generally measured as root mean square (rms). That is, the responsivity is denoted by the following expression.

$$R = \frac{rms \text{ of } V0}{rms \text{ of } Pin} [V/W] \qquad (3.39)$$

[Document ②]

Japan Laser Corp.

...

A transfer function of a photodetector or a photoreceiver. With a V/W unit, this indicates a voltage outputted in response to predetermined optical input power.

電気・電子工学大系 ⑮

光電変換デバイス

東京芝浦電気株式会社・理学博士
前田敬二 ほか 共著

コロナ社

添付資料 ① -1
Document ① -1

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表 3・4 赤外線検出器の熱形と光子形の比較

	熱形	光子形
スペクトル特性	平たん	選択性があり，ピークがある
感度	低い (1〜10 V/W)	高い (10^3〜10^5 V/W)
応答速度	遅い (10^{-1}〜10^{-3} s)	速い (10^{-6}〜10^{-9} s)
使用温度	常温 (300K)	冷却の必要 (77K 以下)
例	サーモパイル，ボロメータ，ゴーレイセルなど	InSb, CdHgTe, PbSnTe, Ge(Au), Ge(Hg) など

外の Ge(Hg) や Ge(Cu) については液体ヘリウム温度の冷却が必要となる．これらの感度特性を図 3・41 にまとめて示す．

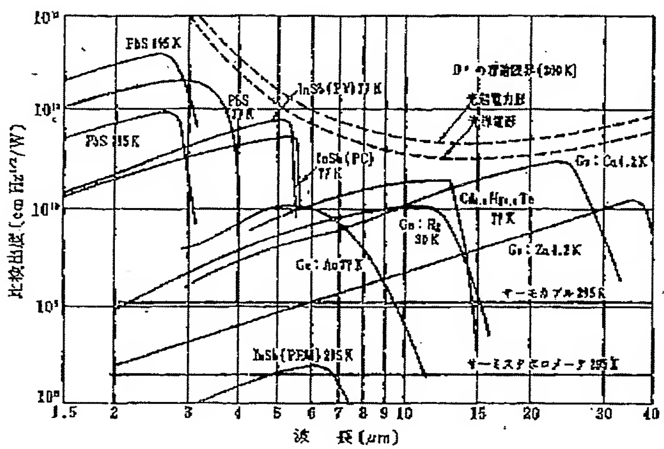

図 3・41 各種赤外線検出器の分光特性

3・5・1 比検出度

検出器の使用にあたって，それから発生する雑音 (noise) がシステムの実際的な特性を制限する重要な因子となる場合が多い．これは，もしそのシステムの他の構成部品 (たとえば増幅器) の雑音が十分小さく抑えてあれば，検出器の S/N 比によって系の最終特性が決められてしまうからである．光電変換素子全般について雑音の問題はたいせつであるが，赤外線検出器では特に素子特性の

Document D-2

重要な要素の一つになるので，ここでその評価のための用語の定義を述べる．

赤外線の受光面に入る入力 P_{in} に対し，信号は一般に電圧 V_s として取り出すので，出力電圧 V_s との比で感度 (responsivity) を定義する．このとき，入力光はチョッピング (chopping) され，出力も電圧パルスで出てくるから，いずれも実効値 (rms) で測定されるのが普通である．すなわち，感度 R は

$$R=\frac{V_s \text{ の rms 値}}{P_{in} \text{ の rms 値}} \quad [\mathrm{V/W}] \qquad (3\cdot39)$$

で表される．検出すべき光入力は検出器の信号がその雑音レベル以下の場合には測定不可能となる．したがって，S/N 比が 1 になるような入力が検出しうる最小入力値である．これを検出器の雑音等価入力 (noise equivalent power) と呼び，NEP と略す．NEP の定義は次式で与えられる．

$$\mathrm{NEP}=\frac{V_N}{R} \quad [\mathrm{W}] \qquad (3\cdot40)$$

ここに，V_N は検出器の雑音電圧である．

現在もっともよく用いられる検出器の評価値としては比検出度 (specific detectivity) があり，D^* で表す[4]．これは NEP の逆数を受光面積 A と増幅系のバンド幅 Δf で標準化したものであり，次式で与えられる．

$$D^*=\frac{(A\Delta f)^{1/2}}{(\mathrm{NEP})} \quad [\mathrm{cm\,Hz^{1/2}/W}] \qquad (3\cdot41)$$

D^* の値は，黒体炉を赤外光源として測定した場合には，黒体炉の温度 T[K] とチョッピング周波数 f[Hz] を入れて，$D^*(T,f)$ で表現する．たとえば，$D^*(500, 800, 1)$ は，黒体炉の温度が 500 K で，チョッピング周波数が 800 Hz で，1 Hz あたりのノイズで測定した D^* ということになる．ときには更に測定視野角 FOV (field of view) を入れることもある．FOV が小さいほど D^* は大きくなる．また，スペクトル応答のピーク値で D^* を測定した場合には，特に区別して $D^*_{\lambda p}$ で表し，λ の値を示すことになっている．

3・5・2 赤外線検出素子

(a) 硫化鉛　近赤外領域で，波長 3 μm ぐらいまでの赤外光の検出

Document ②

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テクニカルインフォメーション

フォトディテクタ特性定義 (New Focus) (Bookham)

お問い合せ

3-dB Bandwidth (3dB バンド幅)

ディテクタの電気出力が低周波数参照値から3dBだけ低下する周波数幅。New Focus社では光学的3dBよりも値が小さい電気的3dB(光学的3dBは電気的な6dB周波数と等価)を規定しています。

Common-Mode Rejection Ratio (CMRR, 同相信号除去比)

New Focus™社のバランスフォトレシーバにおいてCMRRは、そのフォトレシーバを使用したときに除去されるノイズの程度を示します。CMRRの定義は、

$$\mathrm{CMRR} = 20\log_{10}\left(\frac{V_{CM}}{V_{BAL}}\right)$$

ここで V_{CM} は規定周波数におけるフォトディテクタの出力電圧(リファレンスとシグナルダイオードのレーザパワーに比例する)、V_{BAL} は、これと同じ周波数におけるバランスフォトレシーバの出力電圧です。

CW Saturation Power (CW光飽和パワー)

ディテクタ出力が非線形化するパワー地点です。New Focus社の<下線>≦1GHz フォトディテクタで、この値は最初のステージにあるアンプで制約されます。なおこの値は最大応答性をもつ波長において規定されています。

Gain Flatness (利得平坦性)

New Focus社製アンプにおいて、全周波数範囲でのゲイン変動を示します。例えばModel 1421のゲインは、7~10dBの間で変動します。これを電圧ゲインに換算すると、2.2~3.2dBの変動に相当します。

Impulse Resonse (インパルス応答)

高速の光学パルスに対するディテクタ出力の応答幅で、半値幅(FWHM)で表されます。

Maximum Conversion Gain (最大変換利得)

フォトディテクタやフォトレシーバの伝達関数です。V/W単位で、規定の光入力パワーからどの程度の電圧が出力されるかを示します。
フォトレシーバの変換利得は、フォトディテクタの応答性(R)、アンプのゲイン(A_g)、入力インピーダンス(R_{in})から得られます。アンプの内蔵されていないフォトディテクタの変換利得は、フォトディテクタの応答性と負荷のインピーダンス(R_l)から求められます。

$$\text{Conversion Gain } (G) = R\,A_g\,R_{in} \text{ (receivers)}$$
$$= R \cdot R_l \text{ (detectors)}$$

出力電圧の測定値は、変換利得と光入力パワー(P_{in})から求められます。フォトレシーバの場合、

$$\text{Output Voltage} = G\,P_{in}$$
$$= R\,A_g\,R_{in}\,P_{in}$$

Maximum Optical Power (最大光パワー)

フォトディテクタのダメージ閾値で、ピーク応答時の波長で規定されます。

significant part in the impedance determination. After a "self-resonant point" is passed, the impedance always becomes capacitive and starts to decrease with frequency.

Temperature coefficient of resistance Because resistors are heat-producing devices and can be expected to perform over a wide ambient temperature range, their ability to remain stable in resistance value over a wide range of temperatures is important. The term *coefficient* is used to denote a variation that is small or essentially linear, and temperature characteristic is used to define a wide nonlinear variation, confined mostly to carbon-composition resistors. Coefficients given in parts per million per degree C (ppm/°C), percent per degree C (which is parts per hundred per degree C), percent per degree C (which is parts per hundred per degree C), or sometimes just a decimal coefficient number per degree C are valid only within the temperature range specified and are defined for the temperature average of the resistor body, rather than the surrounding air temperature. Self-heating caused by the power being dissipated thus must be included in the determinations.

Power derating curves provide maximum hot-spot temperature information for free-air mountings, but almost always will give a very conservative estimate. This is apparently because limitation on resistance changes in operating load life is a more compelling design constraint than hot-spot temperature limits.

Resistors are designed to operate at given maximum temperatures dependent on the materials used. At full rated power, therefore, a high-temperature resistor will experience more resistance change for a given temperature coefficient of resistance than will a lower-temperature part or one that is operated at a fraction of its rated power. This consideration should be made when selecting resistor types. Resistance variation as a proportion of the total value tends to be greater with very low values of resistance, approximately 5 ohms or less. This is because lead-wire resistance, thermal elongations, and variables, such as end-cap contact resistance, are insignificant at higher resistances. Standards and specifications generally recognize this by allowing wider variations for low values. A means of calculating the temperature coefficient is given by Eq. 1-5.

$$R_2 = R_1 \left(\frac{1 + \alpha\theta 2}{1 + \alpha\theta 1} \right) \qquad (1.5^3)$$

α = temperature coefficient (ppm/°C)
R_1 = known resistance at temperature T_1
R_2 = known resistance at temperature T_2
O_2 = temp 2 (°C)
O_1 = temp 1 (°C)

Voltage coefficient of resistance Changes in conductivity caused by higher potential gradients across molecular interfaces cause resistivity to vary slightly with applied voltage. This is expressed as a coefficient of the nominal resistance (percent or parts per million) per volt. This quantity is specified to be independent of effect because of self heating, and measurement is thus difficult. The effect varies from –700 ppm/V for the higher resistance values of carbon composition through about 5 to 30 ppm/V for carbon film and cermet, and from 10 to 0.005 ppm/V for metal film and oxide films, although some thick-film types go as high as 400 ppm/V. The voltage coefficient is not usually of consequence for wirewound resistors.

Resistor noise The noise output of a given resistor depends on its thermal "white" noise, plus a noise output from the applied current. The latter portion depends on the resistor design, and the former (Johnson noise) depends on the resistance and its temperature:

$$\text{(Johnson) } E_{rms} = 7.4\sqrt{RT\,\Delta f} \times 10^{-12} \qquad (1.6^3)$$

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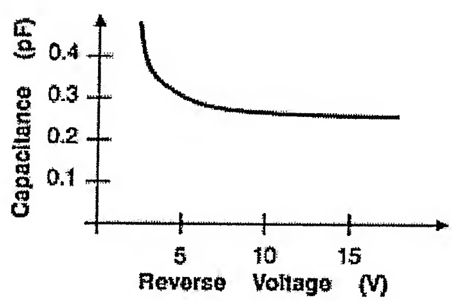
Fiber Optic Detectors

Detectors perform the opposite function of light emitters. They convert optical signals back into electrical impulses that are used by the receiving end of the fiber optic data, video, or audio link. The most common detector is the semiconductor photodiode, which produces current in response to incident light. Detectors operate based on the principle of the p-n junction. An incident photon striking the diode gives an electron in the valence band sufficient energy to move to the conduction band, creating a free electron and a hole. If the creation of these carriers occurs in a depleted region, the carriers will quickly separate and create a current. As they reach the edge of the depleted area, the electrical forces diminish and current ceases. While the p-n diodes are insufficient detectors for fiber optic systems, both PIN photodiodes and avalanche photodiode (APDs) are designed to compensate for the drawbacks of the p-n diode.

Important Detector Parameters

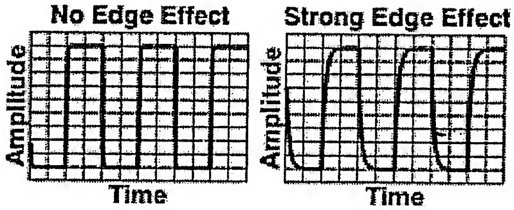
- Responsivity: Ratio of current output to light input. High responsivity equals high receiver sensitivity.
- Quantum Efficiency: Ratio of primary electron-hole pairs created by incident photons to the photons incident on the detector material.
- Capacitance: Dependent upon the active area of the device and the reverse voltage across the device. This relationship is illustrated in Figure 1.
- Response Time: Time needed for the photodiode to respond to optical inputs and produce and external current.

Figure 1 – C-V Curve



Response time can be affected by dark current, noise, linearity, backreflection, and edge effect (see Figure 2). Edge effect results from the fact that detectors only provide fast response in their center region. The outer region of the detector

Figure 2 – Edge Effect

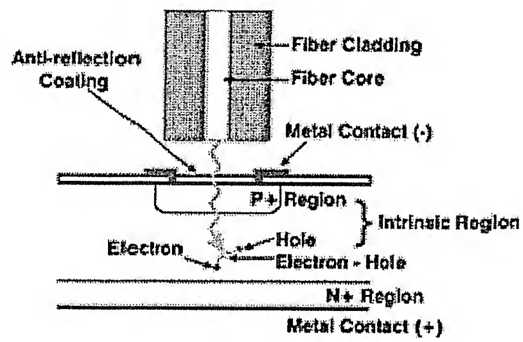


has a higher responsivity than the center region, which can cause problems when aligning the fiber to the detector. The higher responsivity may fool one into thinking they have aligned the fiber to the center region. Because response is much slower at the edge, this misalignment will reduce the response time of the detector.

PIN Photodiode

A p-n diode's deficiencies are related to the fact that the depletion area (active detection area) is small; many electron-hole pairs recombine before they can create a current in the external circuit. In the PIN photodiode, the depleted region is made as large as possible. A lightly doped intrinsic layer separates the more heavily doped p-types and n-types. The diode's name comes from the layering of these materials positive, intrinsic, negative — PIN. Figure 3 shows the cross-section and operation of a PIN photodiode.

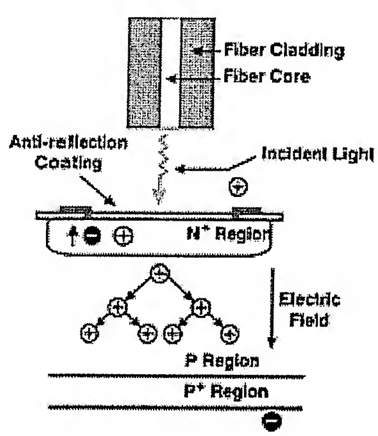
Figure 3 – PIN Photodiode



Avalanche Photodiode (APD)

The avalanche photodiode (APD) operates as the primary carriers, the free electrons and holes created by absorbed photons, accelerate, gaining several electron Volts of kinetic energy. A collision of these fast carriers with neutral atoms causes the accelerated carriers to use some of their own energy to help the bound electrons break out of the valence shell. Free electron-hole pairs, called secondary carriers, appear. Collision ionization is the name for the process that creates these secondary carriers. As primary carriers create secondary carriers, the secondary carriers themselves accelerate and create new carriers. Collectively, this process is known as photomultiplication. Typical multiplication ranges in the tens and hundreds. For example, a multiplication factor of eighty means that, on average, eighty external electrons flow for every photon of light absorbed.

Figure 4 – APD



APDs require high-voltage power supplies for their operation. The voltage can range from 30 or 70 Volts for InGaAs APDs to over 300 Volts for Si APDs. This adds circuit complexity. Also, APDs are very temperature sensitive, further

complicating circuit requirements. In general, APDs are only useful for digital systems because they possess very poor linearity. Because of the added circuit complexity and the high voltages that the parts are subjected to, APDs are always less reliable than PIN detectors. This, added to the fact that at lower data rates, PIN detector-based receivers can almost match the performance of APD-based receivers, makes PIN detectors the first choice for most deployed low-speed systems. At multigigabit data rates, however, APDs rule supreme.

Table 1 – Comparison of PIN Photodiodes and APDs

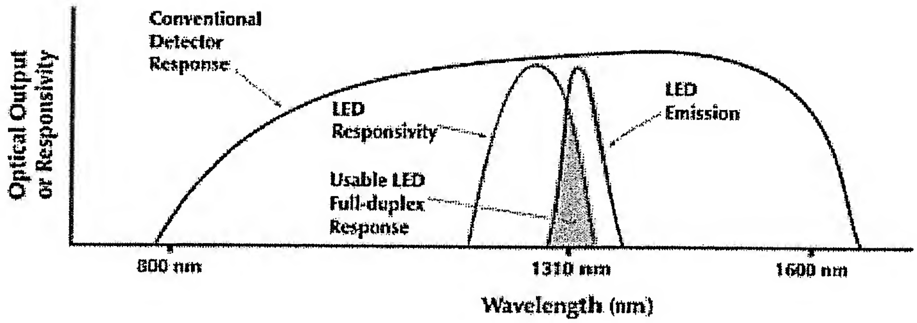
Parameter	PIN Photodiodes	APDs
Construction Materials	Si, Ge, InGaAs	Si, Ge, InGaAs
Bandwidth	DC to 40+ GHz	DC to 40+ GHz
Wavelength	0.6 to 1.8 µm	0.6 to 1.8 µm
Conversion Efficiency	0.5 to 1.0 Amps/Watt	0.5 to 100 Amps/Watt
Support Circuitry Required	None	High Voltage, Temperature Stabilization
Cost (Fiber Ready)	$1 to $500	$100 to $2,000

Light Emitters As Detectors

Light emitter such as LEDs and lasers, will also function as light detectors, allowing a unique technology to evolve, using light emitters as half-duplex fiber optic communication devices. This scheme involves using the LED or laser alternately as a light emitter, then as a light detector, which allows the transmission of information in either direction over the fiber. While all LEDs and lasers have the ability to act as detectors, a few perform this task much better than most. The key parameter to look for is very efficient coupling between the light emitter and the fiber. This allows good performance in both modes. It is also important that the LEDs have consistent spectral characteristics. While a good InGaAs detector may have a responsivity of 0.8 A/W at a wavelength of 1310 nm, an LED operating as a detector may provide a responsivity of 0.08 A/W at 1310 nm.

The main reason for the much lower response is the fact that the LED operating as a detector has a relatively narrow spectral response spectrum that does not fully overlap with the LED emission spectrum. Figure 5 shows the spectral response of a typical InGaAs detector as well as the emission spectrum of an InGaAsP LED and the LEDs spectral response as a detector. It can be seen that a normal InGaAs detector has a very broad spectral response from 800 nm to beyond 1600 nm. Because the response is so wide, the detector responds to all photons emitted by the LED. The spectral emission of the LED is a relatively narrow spectrum, perhaps 60 nm wide, centered around 1310 nm. Notice that the spectral response of the same LED operating as a detector is shifted to the left. The center of the spectral response is centered at perhaps 1270 nm. The overall response as a detector is a bit wider than the emissions as an LED. However, note that the overlap between the LED emissions and the LED spectral response is rather low. This accounts for poor responsivity attributed to most LEDs operating as detectors. The problem becomes even worse when the emitting LED and the detecting LED are at different operating temperatures. This causes the individual spectral responses to drift with respect to each other. This will either increase or decrease the amount of overlap. The overwhelming concern when applying full-duplex LEDs is considering the different temperatures that the two ends will see. Laser diodes exhibit similar characteristics to the LED shown in Figure 5.

Figure 5 - Ping-Pong (Full-Duplex) LED



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